Classical Explanation of Absorption Spectra

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Abstract

This paper discusses the difficulties in interpreting the absorption spectra of a particular monoatomic gas filled in a chamber with perfectly reflective inner walls. If those gas atoms absorb photons of frequency v from white light falling on them, how they can continue to absorb them cannot be explained on the lines of conservation of energy, which is always overlooked. This paper traces that there is something else here that is not yet understood. One thing that to understand is that if an atom produces a light wave of frequency v, the electron that generated this wave due to its transition must oscillate at one place in the atom with that frequency which can be the natural frequency of that electron at that place. But no atomic model is in a position to support this. When a light wave of the same frequency interacts with the same electron of the atom, it should oscillate at the same frequency in resonance. But if there is a difference of 180 degrees between the light wave created by the oscillations of that electron and the light wave interacting that electron, no net wave can be created or come out, so a black line will appear at the frequency v at absorption spectrum of gas of such atoms. No matter how long light is shone on that gas, this condition will remain forever.

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1. Introduction

Absorption spectroscopy is primarily used as an analytical chemistry tool to determine the presence or quantity of a particular substance in a sample. Among them, Atomic Absorption Spectroscopy (AAS), a simple but relatively expensive technology, is widely used to identify elements in elemental solutions. Technique used in absorption spectroscopy is that when a radiation interacts with a sample, it absorbs some part of it which can be function of frequency or wavelength. The chemical information of that compound can be extracted from it. A substance that emits radiation also absorbs the same kind of radiation, so the emission spectrum gives as much information about the substance as the absorption spectrum. Kirchhoff first showed in 1859 that the Fraunhofer lines seen in the sun were actually atomic absorption lines and that they were produced by various elements in the sun's atmosphere. Further Kirchhoff and Bunsen showed that different elements in a flame can give characteristic emission and absorption spectra. This gave rise to emission spectroscopy. For the next hundred years or so, much emphasis was placed on emission spectroscopy, perhaps Kirchhoff and Bunsen's measurements were used only for visible light. But later it was noticed that atomic absorption methods could offer many potential advantages over emission methods [1][2][3][4]. This initially posed a problem in automating the sample from which emission and absorption spectra were to be obtained, but over time research has evolved into different methods of automating the sample and improving the application of spectroscopy [5][6][7]. But one thing to note is that no matter how advanced the techniques in emission and absorption spectroscopy are, there is still no clarity as to what exactly is going on where photons are emitted or absorbed. It is unfortunate that when an atom emits a light wave, the electron that generated the light wave must oscillate to a place in that atom at the frequency of the light wave which is not accepted yet and not anyone tried to search in this direction. That is, the natural frequency of oscillations of that electron should be at the place in the atom where the corresponding electron oscillates and creates the light wave. This means that when a light wave of the same frequency interacts with that electron, it will oscillate at the same frequency which is its natural frequency of oscillations which can be called as resonance. So, this paper tries to find out what exactly is going on there.

A hypothetical experiment on the absorption spectra of a monatomic gas confined in a chamber and its expected results are discussed in the next section. Section 3 discusses in detail how and why the expected results of an experiment can be justified by aspects of quantum mechanics and classical mechanics. Section 4 contains the conclusions.

2. Experimental arrangement and expected results

For this a gas chamber can first be constructed as shown in Fig. 1, with two windows facing each other. The surface inside the gas chamber is perfectly reflective and is filled with a suitable monatomic gas to obtain its absorption spectra. White light enters through window W_1 and pass straight through the gas and exit through window W_2. The emitted light is analysed using a spectrometer with a prism. Suppose, according to quantum mechanics, the gas atoms absorb photons of the frequency v, then in the light coming out of the gas, these photons will be absent. So, in the dispersion spectra produced by the prism, called the absorption spectra of the monatomic gas, a black line appears whose wavelength is λ=c/v. Now, no matter how long the light through window W_1 is put on the gas, there will be no change in the absorption spectra, i.e. the black line will remain.

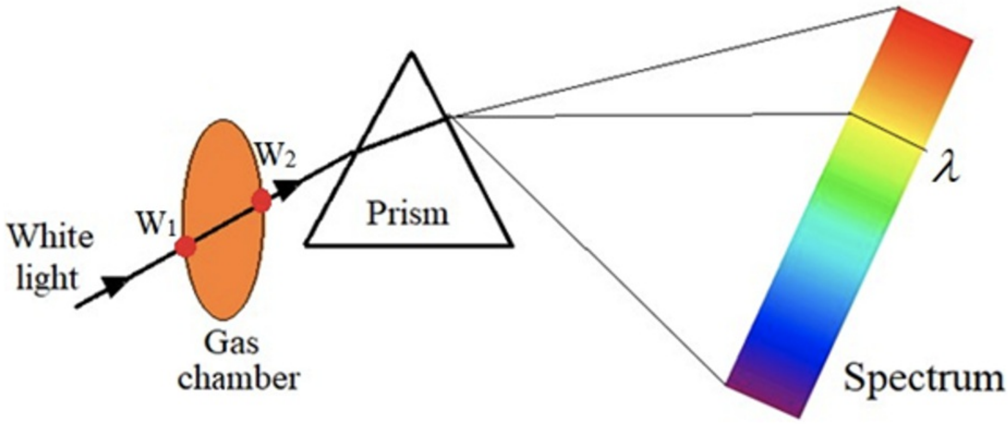

Figure 1. Experimental arrangement to obtain absorption spectra of a monatomic gas.

3. Discussion

In the above experiment, no matter how long the white light through window W_1 is thrown on the gas, if the black line in its absorption spectra remains, it means that the gas atoms in that chamber are constantly absorbing photons of v frequencies. Suppose there are a total of n atoms of gas in that gas chamber, then any one of the following possibilities should occur.

- All the n atoms of the gas in the chamber absorbs n number of photons of frequency v from the incoming white light and go into excited state after which no photon of the frequency v gets absorbed because of which the black line disappears again from the absorption spectra.
- n atoms in the gas absorbs photons of frequency v from the incoming white light and, according to their local conditions, go into excited state and re-emit photons of the same frequency and come to ground state. This process repeats continuously. Even if the re-emitted photons are assumed to go in any direction, since the internal wall of the chamber is perfectly reflective, either the photons will be reabsorbed by some gas atoms which will be re-emitted again. This means that in the absorption spectra that black line should disappear again.

According to the classical expectations, light is an electromagnetic wave and if the frequency of a light wave is v, it is a universal truth that the electron transition in the atom that created this wave should oscillate with this frequency at a place in the atom. There is no other option. But no one seems to be thinking about this. Each one relies on the equation E_1-E_2 = hv. But no one knows anything about how that electron oscillates at the frequency$v$ and it is a matter of surprise that there is no any mention of it. The cause of this situation is the prevailing atomic models. Two atomic models seem to be accepted till date, one is the Rutherford-Bohr atomic model and the other is the Cloud atomic model. In the Rutherford-Bohr atomic model, the electrons are assumed to be moving continuously in orbits so that their centripetal and centrifugal forces are balanced. Therefore, there is no question of an electron oscillating in a stationary position in an atom, so this model cannot throw any light on how the energy difference of the electron is converted into a light wave. Despite the many problems with this atomic model, it is surprising that it is featured in the logos of many International Atomic Energy

Agencies or Institutes. The first thing is that if an electron moves in an orbit, it will radiate energy because an electron has its own electric field, so it will create electric field ripples while moving in an orbit, so its speed will slow down and eventually it will fall into a nucleus, which no one can stop. Yet Bohr introduced the concept of stationary orbit which was not to be accepted under any circumstances and it was to be decided that the electron could not move in an orbit under any circumstances [8]. Further, no one can explain how the net orbital magnetic moment of the paired electrons becomes zero, or how the centripetal force and the centrifugal force balance immediately after an electron jumps from one orbit to another. This means that electrons cannot move in orbits under any circumstances in atoms. So, another discovery should have been made as to how electrons can stay away from the nucleus of atoms but it did not happen. Einstein later proposed light quanta to explain the photoelectric effect [9]. In fact, it was known at the time that light is an electromagnetic wave and how its electric and magnetic fields can exert forces on electrons in the photoelectric effect, so it had to be considered. Why nobody thought of these forces is an unsolved puzzle. Everyone stuck on the same thing that as the intensity of light increases, the energy in it should increase. So, the classical solution of photoelectric effect could not be found. If the forces was considered at that time, it would have been realized that the asymmetric electric field in the light wave is responsible for the photoelectric effect. Not only this, but it is responsible for creating the magnetic field effect and the answer to why magnetic monopoles are not found in the universe would have been revealed and physics today could have been seen following a different path. But still, no one seems to consider the forces to solve the photoelectric effect. However, due to Einstein's proposal of light quanta, light came to be regarded as a particle rather than a wave. From this, de Broglie proposed that if a particle is in motion, it can be expressed as a wave. Using this, Schrödinger predicted where the electron might be in the hydrogen atom, assuming the electron to be a wave rather than a particle, which is called the cloud atomic model. This further complicates the subject of the atom, which is not in a position to predict how an electron will oscillate at that frequency while emitting a light wave. It is a universal truth that the corresponding electron in that atom must oscillate at the frequency at which the light wave emits. The first condition for this would be that all the electrons in the atom should not move in orbits. The only alternative left is that if the two electrons are in opposite spin motion about the same axis, their net spin magnetic moment becomes zero and magnetic repulsion is created between them. If there is a positive core between them as a nucleus, the net attractive force between the nucleus and the electrons and the net electric and magnetic repulsion between these two electrons can be balanced, so they can be fixed at a certain distance from the nucleus. Such atomic model can be called as a ‘Spin Atomic Model’, which further must be refined [10]. So that it will be possible to get the information about how electrons settle in different shells and how much their total energy is and at what frequency it can oscillate at that place. But until then, this indicates that electrons can be fixed in atoms due to their spin motions, which is why they can oscillate around their mean positions and produce light waves or electromagnetic waves. Another possibility arises from this is that there should be a natural frequency of the electron at the place where it is fixed in the atom. How far it jumps to that point should not make a difference in the frequency, but the amplitude of the oscillations should make a difference. The natural frequency of oscillations of that electron at that point must depend on the forces that stabilize the electron at that point. From this one can make some predictions about what is happening in the absorption spectra.

Suppose an electron in an atom, where it is fixed, has the natural frequency of oscillations, and if an electromagnetic wave or light wave of the same frequency interacts with that electron, it will oscillate with the same frequency, it is called resonance. In fact, the magnetic field is an effect of the asymmetric electric field, so there is only the electric field in the light wave. Now when the light wave interacts with the electron, the displacement of the electron will be in the opposite direction to the electric field in the light wave. But the oscillations of electrons will also produce a light wave or an electric field wave. If the direction of the electric field of the applied light wave and the direction of the electric field created by the electron are opposite to each other, i.e. the two waves have a phase difference of 180 degrees, then the effective electric field will be zero. No wave will come out of that process and the process will be continuous. Therefore, a black line will always appear in the absorption spectra at that frequency or at the corresponding wavelength. There can be no other option. Of course, this will raise many questions that need to be answered.

If sodium atom is considered, when it emits a photon of v_1 frequency corresponding to D_1 line, it is supposed that the electron in $^3P_{1/2}$ jumps to $^3S_{1/2}$, while when it emits a photon of n_2 frequency corresponding to D_2 line, the electron in $^3P_{3/2}$ jumps to $^3S_{1/2}$ level. This means that even if either photon is emitted, the electron eventually settles in the $^3S_{1/2}$ level. Now if the same atom is exposed to a white light, which contains photons of all frequencies in the range of visible light then only v_1 or v_2 frequency photons can be absorbed and the electron can go back to $^3P_{1/2}$ or $^3P_{3/2}$ level. Now it is a mystery how that atom or that electron can determine exactly which photons of these two frequencies are to be absorbed out of all the incoming photons of all frequencies. Also, when both photons are available in that light, it is also miraculous how exactly which atom can decide which photon to absorb, since in all atoms the related electrons are settled at level $^3S_{1/2}$. In fact, there may be something different. To be clear, when an atom is considered to be emitting a photon of frequency v_1, the corresponding electron in that atom must be oscillating with that frequency v_1 which must be the natural frequency of oscillations of that electron at that place where it oscillates. Of course, it cannot depend on where the electron came from in that place. Also, if the two frequencies v_1 and v_2 are different, there should be two places for that electron in that atom where that electron can oscillate with those two frequencies. If the electron is at the position of natural frequency v_1 in the atom, then it will resonate with the wave of frequency n_1 from the incoming white light which will be wave will be annihilated as discussed above. If that electron is at the position of natural frequency v_2 in the atom, then it will resonate with the wave of frequency v_2 which will be annihilated. Here the electron has no choice to make any decision. This truth must be understood sometime.

4. Conclusions

When atom emits a light wave, the concerned electron, because transition of which the light wave is crated, must vibrate at a place in the atom with the frequency of the light wave. That electron should have natural frequency of oscillations at that position in the atom. Therefore, the electrons in the atoms are not moving in orbits. They can maintain their safe distance from the nucleus by adjusting their spin motions. If light wave of natural frequency of the electron at that place in the atom interacts with that electron, it will start to oscillate with that frequency and comes into resonance. If the light wave generated by the oscillations of the electron and the light wave interacting with the electron are 180 degrees out of phase then there will be no resultant wave produced. If the interacting light wave with the electron has frequency different from the natural frequency of that electron at its place in the atom, there will be no resonance and no annihilation consequently the interacting light wave will come out.

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